Reinforcement Learning An Introduction Richard S Sutton

Foundations of Deep Reinforcement Learning

Deep Reinforcement Learning

This book considers large and challenging multistage decision problems, which can be solved in principle by dynamic programming (DP), but their exact solution is computationally intractable. We discuss solution methods that rely on approximations to produce suboptimal policies with adequate performance. These methods are collectively known by several essentially equivalent names: reinforcement learning, approximate dynamic programming, neuro-dynamic programming. They have been at the forefront of research for the last 25 years, and they underlie, among others, the recent impressive successes of self-learning in the context of games such as chess and Go. Our subject has benefited greatly from the interplay of ideas from optimal control and from artificial intelligence, as it relates to reinforcement learning and simulation-based neural network methods. One of the aims of the book is to explore the common boundary between these two fields and to form a bridge that is accessible by workers with background in either field. Another aim is to organize coherently the broad mosaic of methods that have proved successful in practice while having a solid theoretical and/or logical foundation. This may help researchers and practitioners to find their way through the maze of competing ideas that constitute the current state of the art. This book relates to several of our other books: Neuro-Dynamic Programming (Athena Scientific, 1996), Dynamic Programming and Optimal Control (4th edition, Athena Scientific, 2017), Abstract Dynamic Programming (2nd edition, Athena Scientific, 2018), and Nonlinear Programming (Athena Scientific, 2016). However, the mathematical style of this book is somewhat different. While we provide a rigorous, albeit short, mathematical account of the theory of finite and infinite horizon dynamic programming, and some fundamental approximation methods, we rely more on intuitive explanations and less on proof-based insights. Moreover, our mathematical requirements are quite modest: calculus, a minimal use of matrix-vector algebra, and elementary probability (mathematically complicated arguments involving laws of large numbers and stochastic convergence are bypassed in favor of intuitive explanations). The book illustrates the methodology with many examples and illustrations, and uses a gradual expository approach, which proceeds along four directions: (a) From exact DP to approximate DP: We first discuss exact DP algorithms, explain why they may be difficult to implement, and then use them as the basis for approximations. (b) From finite horizon to infinite horizon problems: We first discuss finite horizon exact and approximate DP methodologies, which are intuitive and mathematically simple, and then progress to infinite horizon problems. (c) From deterministic to stochastic models: We often discuss separately deterministic and stochastic problems, since deterministic problems are simpler and offer special advantages for some of our methods. (d) From model-based to model-free implementations: We first discuss model-based implementations, and then we identify schemes that can be appropriately modified to work with a simulator. The book is related and supplemented by the companion research monograph Rollout, Policy Iteration, and Distributed Reinforcement Learning (Athena Scientific, 2020), which focuses more closely on several topics related to rollout, approximate policy iteration, multigagent problems, discrete and Bayesian optimization, and distributed computation, which are either discussed in less detail or not covered at all in the present book. The author's website contains class notes, and a series of videos and slides from a 2021 course at ASU, which address a selection of topics from both books.

Deep Reinforcement Learning

Summary Deep learning has transformed the fields of computer vision, image processing, and natural language applications. Thanks to TensorFlow.js, now JavaScript developers can build deep learning apps without relying on Python or R. Deep learning with JavaScript shows developers how they can bring DL technology to the web. Written by the main authors of the TensorFlow library, this new book provides fascinating use cases and in-depth instruction for deep learning apps in JavaScript in your browser or on Node. Foreword by Nikhil Thorat and Daniel Smilkov. About the technology Running deep learning applications in the browser or on Node-based backends opens up exciting possibilities for smart web applications. With the TensorFlow.js library, you build and train deep learning models with JavaScript. Offering uncompromising production-quality scalability, modularity, and responsiveness, TensorFlow.js really shines for its portability. Its models run anywhere, even in the application stack. About the book In Deep Learning with JavaScript, you’ll learn to use TensorFlow.js to build deep learning models that run directly in the browser. This fast-paced book, written by Google engineers, is practical, engaging, and easy to follow. Through diverse examples featuring text analysis, speech processing, image recognition, and self-learning game AI, you’ll master all the basics of deep learning and explore advanced concepts, like retraining existing models for transfer learning and image generation. What’s inside - Image and language processing in the browser - Tuning ML models with client-side data - Text and image creation with generative deep learning - Source code samples to test and modify - The reader For JavaScript programmers interested in deep learning. About the author Shanging Cai, Stanley Bileschi and Eric D. Nielsen are software engineers with experience on the Google Brain team, and were crucial to the development of the high-level API of TensorFlow.js. This book is based in part on the classic, Deep Learning with Python by François Chollet. TOC: PART 1 - MOTIVATION AND BASIC CONCEPTS 1 • Deep learning and Java-Script PART 2 - A GENTLE INTRODUCTION TO TENSORFLOWJS 2 • Getting started: Simple linear regression in TensorFlow.js 3 • Adding nonlinearity: Beyond weighted sums 4 • Recognizing images and sounds using convnets 5 • Transfer learning: Reusing pretrained neural networks PART 3 - ADVANCED DEEP LEARNING WITH TENSORFLOWJS 6 • Working with data 7 • Visualizing data and models 8 • Underfitting, overfitting, and the universal workflow of machine learning 9 • Deep learning for sequences and text 10 • Generative deep learning 11 • Basics of deep reinforcement learning PART 4 - SUMMARY AND CLOSED WORDS 12 • Testing, optimizing, and deploying models 13 • Summary, conclusions, and beyond

Reinforcement Learning, second edition

Reinforcement learning is a learning paradigm concerned with learning to control a system so as to maximize a numerical performance measure that expresses a long-term objective. What distinguishes reinforcement learning from supervised learning is that only partial feedback is given to the learner about the learner’s predictions. Further, the predictions may have long term effects through influencing the future state of the controlled system. Thus, time plays a special role. The goal in reinforcement learning is to develop efficient learning algorithms, as well as to understand the algorithms' merits and limitations.
Reinforcement learning is of great interest because of the large number of practical applications that it can be used to address, ranging from problems in artificial intelligence to operations research or control engineering. In this book, we focus on those algorithms of reinforcement learning that build on the powerful theory of dynamic programming. We give a fairly comprehensive catalog of learning problems, describe the core ideas, note a large number of state of the art algorithms, followed by the discussion of their theoretical properties and limitations.

Reinforcement Learning and Optimal Control

Reinforcement Learning (RL) is a very dynamic area in terms of theory and application. This book brings together many different aspects of the current research on several fields associated to RL which has been growing rapidly, producing a wide variety of learning algorithms for different applications. Based on 24 Chapters, it covers a very broad variety of topics in RL and their application in autonomous systems. A set of chapters in this book provide a general overview of RL while other chapters focus mostly on the applications of RL paradigms: Game Theory, Multi-Agent Theory, Robotics, Networking Technologies, Vehicular Navigation, Medicine and Industrial Logistic.

Deep Reinforcement Learning with Python

Master reinforcement learning, a popular area of machine learning, starting with the basics: discover how agents and the environment evolve and then gain a clear picture of how they are inter-related. You’ll then work with theories related to reinforcement learning and see the concepts that build up the reinforcement learning process. Reinforcement Learning discusses algorithm implementations important for reinforcement learning, including Markov’s Decision process and Semi Markov Decision process. The next section shows you how to get started with OpenAI before looking at OpenAI Gym. You’ll then learn about Swarm Intelligence with Python in terms of reinforcement learning. The last part of the book starts with the TensorFlow environment and gives an outline of how reinforcement learning can be applied to TensorFlow. There’s also coverage of Keras, a framework that can be used with reinforcement learning. Finally, you’ll delve into Google’s Deep Mind and see scenarios where reinforcement learning can be used. What You’ll Learn Absorb the core concepts of the reinforcement learning process Use advanced topics of deep learning and AI Work with OpenAI Gym, OpenAI, and Python Harness reinforcement learning with TensorFlow and Keras using Python Who This Book Is For Data scientists, machine learning and deep learning professionals, developers who want to adapt and learn reinforcement learning.

Reinforcement Learning

From household appliances to applications in robotics, engineered systems involving complex dynamics can only be as effective as the algorithms that control them. While Dynamic Programming (DP) has provided researchers with a way to optimally solve decision and control problems involving complex dynamic systems, its practical value was limited by algorithms that lacked the capacity to scale up to realistic problems. However, in recent years, dramatic developments in Reinforcement Learning (RL), the model-free counterpart of DP, changed our understanding of what is possible. Those developments led to the creation of reliable methods that can be applied even when a mathematical model of the system is unavailable, allowing researchers to solve challenging control problems in engineering, as well as in a variety of other disciplines, including economics, medicine, and artificial intelligence. Reinforcement Learning and Dynamic Programming Using Function Approximators provides a comprehensive and unparalleled exploration of the field of RL and DP. With a focus on continuous-variable problems, this seminal text details essential developments that have substantially altered the field over the past decade. In its pages, pioneering experts provide a concise introduction to classical RL and DP, followed by an extensive presentation of the state-of-the-art and novel methods in RL and DP with approximation. Combining algorithm development with illustrative examples and theoretical analysis, the authors provide a coherent and comprehensive overview of the major classes of techniques: value iteration, policy iteration, and policy search. The features and performance of these algorithms are highlighted in extensive experimental studies on a range of control applications. The recent development of applications involving complex systems has led to a surge of interest in RL and DP methods and the subsequent need for a quality resource on the subject. For graduate students and others new to the field, this book offers a thorough introduction to both the basics and emerging methods. And for those researchers and practitioners working in the fields of optimal and adaptive control, machine learning, artificial intelligence, and operations research, this resource offers a combination of practical algorithms, theoretical analysis, and comprehensive examples that they will be able to adapt and apply to their own work. Access the authors’ website at www.dccs.tudelft.nl/rlbook for additional material, including computer code used in the studies and information concerning new developments.

Semi-Supervised Learning

Markov Decision Processes (MDPs) are a mathematical framework for modeling sequential decision problems under uncertainty as well as Reinforcement Learning problems. Written by experts in the field, this book provides a global view of current research using MDPs in Artificial Intelligence. It starts with an introductory presentation of the fundamental aspects of MDPs (planning in MDPs, Reinforcement Learning, Partially Observable MDPs, Markov games and the use of non-classical criteria). Then it presents more advanced research trends in the domain and gives some concrete examples using illustrative applications.

Reinventing Discovery

Summary Humans learn best from feedback—we are encouraged to take actions that lead to positive results while deterred by decisions with negative consequences. This reinforcement process can be applied to computer programs allowing them to solve more complex problems that classical programming cannot. Deep Reinforcement Learning teaches you the fundamental concepts and terminology of deep reinforcement learning, along with the practical skills and techniques you’ll need to implement it into your own projects. Purchase of the print book includes a free eBook in PDF, Kindle, and ePub formats from Manning Publications. About the technology Deep reinforcement learning AI systems rapidly adapt to new environments, a vast improvement over standard neural networks. A DRL agent learns like people do, taking in raw data such as sensor input and refining its responses and predictions through trial and error. About the book Deep Reinforcement Learning in Action teaches you how to program AI agents that adapt and improve based on direct feedback from their environment. In this example-rich tutorial, you’ll master foundational and advanced DRL techniques by taking on interesting challenges like navigating a maze and playing video games. Along the way, you’ll work with core algorithms, including deep Q-networks and policy gradients, along with industry-standard tools like PyTorch and OpenAI Gym. What’s inside Building and training DRL networks The most popular DRL algorithms for learning and problem solving Evolutionary algorithms for curiosity and multi-agent learning AI examples available as Jupyter Notebooks About the reader For readers with intermediate skills in Python and deep learning, About the author Alexander Zai is a machine learning engineer at Amazon AI. Brandon Brown is a machine learning and data analysis blogger. Table of Contents PART 1 - FOUNDATIONS 1. What is reinforcement learning? 2. Modeling reinforcement learning problems: Markov decision processes 3. Predicting the best states and actions: Deep Q-networks 4. Learning to pick the best policy: Policy gradient methods 5. Tackling more complex problems with actor-critic methods PART 2 - ABOVE AND BEYOND 6. Alternative optimization
Bayes Theorem Examples

A project-based guide to the basics of deep learning. This concise, project-driven guide to deep learning takes readers through a series of program-writing tasks that introduce them to the use of deep learning in such areas as artificial intelligence as computer vision, natural-language processing, and reinforcement learning. The author, a longtime artificial intelligence researcher specializing in natural-language processing, covers feed-forward neural nets, convolutional neural nets, word embeddings, recurrent neural nets, sequence-to-sequence learning, deep reinforcement learning, unsupervised models, and other fundamental concepts and techniques. Students and practitioners learn the basics of deep learning by working through programs in Tensorflow, an open-source machine learning framework. "I find the author computer science material best by sitting down and writing programs," the author writes, and the book reflects this approach. Each chapter includes a programming project, exercises, and references for further reading. An early chapter is devoted to Tensorflow and its interface with Python, the widely used programming language. Familiarity with linear algebra, multivariate calculus, and probability and statistics is required, as is a rudimentary knowledge of programming in Python. The book can be used in both undergraduate and graduate courses; practitioners will find it an essential reference.

Advances in Reinforcement Learning

Grokking Deep Reinforcement Learning uses engaging exercises to teach you how to build deep learning systems. This book combines annotated Python code with intuitive explanations to explore DRL techniques. You’ll see how algorithms function and learn to develop your own DRL agents using evaluative feedback. Summary We all learn through trial and error. We avoid the things that cause us to experience pain and failure. We embrace and build on the things that give us reward and success. This common pattern is the foundation of deep reinforcement learning: building machine learning systems that explore and learn based on the responses of the environment. Grokking Deep Reinforcement Learning introduces this powerful machine learning approach, using examples, illustrations, exercises, and crystal-clear teaching. You’ll love the perfectly paced teaching and the clever, engaging writing style as you dig into this awesome exploration of reinforcement learning fundamentals, effective deep learning techniques, and practical applications in this emerging field. Purchase of the print book includes a free eBook in PDF, Kindle, and ePub formats from Manning Publications. About the technology We learn by interacting with our environment, and the rewards or punishments we experience guide our future behavior. Deep reinforcement learning brings that same natural process to artificial intelligence, analyzing results to uncover the most efficient ways forward. DRL agents can improve marketing campaigns, predict stock performance, and beat grand masters in Go and chess. About the book Grokking Deep Reinforcement Learning uses engaging exercises to teach you how to build deep learning systems. This book combines annotated Python code with intuitive explanations to explore DRL techniques. You’ll see how algorithms function and learn to develop your own DRL agents using evaluative feedback. What’s inside An introduction to reinforcement learning DRL agents with human-like behaviors Applying DRL to complex situations About the reader For developers with basic deep learning experience. About the author Miguel Morales works on reinforcement learning at Lockheed Martin and is an instructor for the Georgia Institute of Technology’s Reinforcement Learning and Decision Making course. Table of Contents 1 Introduction to deep reinforcement learning 2 Mathematical foundations of reinforcement learning 3 Balancing immediate and long-term goals 4 Balancing the gathering and use of information 5 Evaluating agents’ behaviors 6 Improving agents’ behaviors 7 Achieving goals more effectively and efficiently 8 Introduction to value-based deep reinforcement learning 9 More stable value-based methods 10 Sample-efficient value-based methods 11 Policy-gradient and actor-critic methods 12 Advanced actor-critic methods 13 Toward artificial general intelligence

Deep Reinforcement Learning

Bayes theorem describes the probability of an event based on other information that might be relevant. Essentially, you are estimating a probability, but then updating that estimate based on other things that you know. This book is designed to give you an intuitive understanding of how to use Bayes Theorem. It starts with the definition of what Bayes Theorem is, but the focus of the book is on providing examples that you can follow and duplicate. Most of the examples are calculated in Excel, which is useful for updating probability if you have dozens or hundreds of data points to roll in.

Deep Reinforcement Learning Hands-On

An introduction to decision making under uncertainty from a computational perspective, covering both theory and applications ranging from speech recognition to airborne collision avoidance. Many important problems involve decision making under uncertainty—that is, choosing actions based on often imperfect observations, with unknown outcomes. Designers of automated decision support systems must take into account the various sources of uncertainty while balancing the multiple objectives of the system. This book provides an introduction to the challenges of decision making under uncertainty from a computational perspective. It presents both the theory behind decision making models and algorithms and a collection of example applications that range from speech recognition to aircraft collision avoidance. Focusing on two methods for designing decision agents, planning and reinforcement learning, the book covers probabilistic models, introducing Bayesian networks as a graphical model that captures probabilistic relationships between variables; utility theory as a framework for understanding optimal decision making under uncertainty; Markov decision processes as a method for modeling sequential problems; model uncertainty; state uncertainty; and cooperative decision making involving multiple interacting agents. A series of applications shows how the theoretical concepts can be applied to systems for attribute-based person search, speech applications, collision avoidance, and unmanned aircraft persistent surveillance. Decision Making Under Uncertainty unifies research from different communities using consistent notation, and is accessible to students and researchers across engineering disciplines who have some prior exposure to probability theory and calculus. It can be used as a text for advanced undergraduate and graduate students in fields including computer science, aerospace and electrical engineering, and management science. It will also be a valuable professional reference for researchers in a variety of disciplines.

Reinforcement Learning
Deep Reinforcement Learning with Python - Second Edition will help you learn reinforcement learning algorithms, techniques and architectures - including deep reinforcement learning - from scratch. This new edition is an extensive update of the original, reflecting the state-of-the-art latest thinking in reinforcement learning.

**Learning to Play**

The Contemporary Introduction to Deep Reinforcement Learning that Combines Theory and Practice Deep reinforcement learning (deep RL) combines deep learning and reinforcement learning, in which artificial agents learn to solve sequential decision-making problems. In the past decade deep RL has achieved remarkable results on a range of problems, from single and multiplayer games—such as Go, Atari games, and DotA 2—to robotics. Foundations of Deep Reinforcement Learning is an introduction to deep RL that uniquely combines both theory and implementation. It starts with intuition, then carefully explains the theory of deep RL algorithms, discusses implementations in its companion software library SLM Lab, and finishes with the practical details of getting deep RL to work. This guide is ideal for both computer science students and software engineers who are familiar with basic machine learning concepts and have a working understanding of Python. Understand each key aspect of a deep RL problem across policy- and value-based algorithms, including REINFORCE, SARSA, QN, Double QN, and Prioritized Experience Replay (PER) Dive into combined algorithms, including Actor-Critic and Proximal Policy Optimization (PPO) Understand how algorithms can be parallelized synchronously and asynchronously Run algorithms in SLM Lab and learn the practical implementation details for getting deep RL to work Explore algorithm benchmark results with tuned hyperparameters Understand how deep RL environments are designed Register your book for convenient access to downloads, updates, and/or corrections as they become available. See inside book for details.

**Deep Learning**

In this textbook the author takes as inspiration recent breakthroughs in game playing to explain how and why deep reinforcement learning works. In particular he shows why two-person games of tactics and strategy fascinate scientists, programmers, and game enthusiasts and unite them in a common goal: to create artificial intelligence (AI). After an introduction to the core concepts, environment, and communities of intelligent and games, the book is organized into chapters on reinforcement learning, heuristic planning, adaptive sampling, function approximation, and self-play. The author takes a hands-on approach throughout, with Python code examples and exercises that help the reader understand how AI learns to play. He also supports the main text with detailed pointers to online machine learning frameworks, technical details for AlphaGo, notes on how to play and program Go and chess, and a comprehensive bibliography. The content is class-tested and suitable for advanced undergraduate and graduate courses on artificial intelligence and games. It’s also appropriate for self-study by professionals engaged with applications of machine learning and with games development. Finally it’s valuable for any reader engaged with the philosophical implications of artificial and general intelligence, games represent a modern Turing test of the power and limitations of AI.

**Artificial Intelligence**

Richard Sutton and Andrew Barto provide a clear and simple account of the key ideas and algorithms of reinforcement learning. Their discussion ranges from the history of the field's intellectual foundations to the most recent developments and applications. Reinforcement learning, one of the most active research areas in artificial intelligence, is a computational approach to learning whereby an agent tries to maximize the total amount of reward it receives when interacting with a complex, uncertain environment. In Reinforcement Learning, Richard Sutton and Andrew Barto provide a clear and simple account of the key ideas and algorithms of reinforcement learning. Their discussion ranges from the history of the field's intellectual foundations to the most recent developments and applications. The only necessary mathematical background is familiarity with elementary concepts of probability. The book is divided into three parts. Part I defines the reinforcement learning problem in terms of Markov decision processes. Part II provides basic solution methods: dynamic programming, Monte Carlo methods, and temporal-difference learning. Part III presents a unified view of the solution methods and incorporates artificial neural networks, eligibility traces, and planning; the two final chapters present case studies and consider the future of reinforcement learning.

**Bandit Algorithms**

Deep reinforcement learning (DRL) is the combination of reinforcement learning (RL) and deep learning. It has been able to solve a wide range of complex decision-making tasks that were previously out of reach for a machine, and famously contributed to the success of AlphaGo. Furthermore, it opens up numerous new applications in domains such as healthcare, robotics, smart grids and finance. Divided into three main parts, this book provides a comprehensive and self-contained introduction to DRL. The first part introduces the foundations of deep learning, reinforcement learning (RL) and widely used deep RL methods and discusses their implementations. The second part covers selected DRL research topics, which are useful for those wanting to specialize in DRL research. To help readers gain a deep understanding of DRL and quickly apply the techniques in practice, the third part presents mass applications, such as the intelligent transportation system and learning to run, with detailed explanations. The book is intended for computer science students, both undergraduate and postgraduate, who would like to learn DRL from scratch, practice its implementation, and explore the research topics. It also appeals to engineers and practitioners who do not have strong machine learning background, but want to quickly understand how DRL works and use the techniques in their applications.

**Algorithms for Reinforcement Learning**

This book starts by presenting the basics of reinforcement learning using highly intuitive and easy-to-understand examples and applications, and then introduces the cutting-edge research advances that make reinforcement learning capable of out-performing most state-of-art systems, and even humans in a number of applications. The book not only equips readers with an understanding of multiple advanced and innovative algorithms, but also prepares them to implement systems such as those created by Google Deep Mind in actual code. This book is intended for readers who want to both understand and apply advanced concepts in a field that combines the best of two worlds - deep learning and reinforcement learning - to tap the potential of 'advanced artificial intelligence' for creating real-world applications and game-winning algorithms.

**Deep Reinforcement Learning in Action**

Neural networks are a family of powerful machine learning models. This book focuses on the application of neural network models to natural language data. The first half of the book (Parts I and II) covers the
basics of supervised machine learning and feed-forward neural networks, the basics of working with machine learning over language data, and the use of vector-based rather than symbolic representations for words. It also covers the computation-graph abstraction, which allows to easily define and train arbitrary neural networks, and is the basis behind the design of contemporary neural network software libraries.

The second part of the book (Parts III and IV) introduces more specialized neural network architectures, including 1D convolutional neural networks, recurrent neural networks, conditioned-generation models, and attention-based models. These architectures and techniques are the driving force behind state-of-the-art algorithms for machine learning, syntactic parsing, and many other applications. Finally, we also discuss tree-shaped networks, structured prediction, and the prospects of multi-task learning.

Reinforcement Learning, second edition

The significantly expanded and updated new edition of a widely used text on reinforcement learning, one of the most active research areas in artificial intelligence. Reinforcement learning, one of the most active research areas in artificial intelligence, is a computational approach to learning whereby an agent tries to maximize the total amount of reward it receives while interacting with a complex, uncertain environment. In Reinforcement Learning, Richard Sutton and Andrew Barto provide a clear and simple account of the field's key ideas and algorithms. This second edition has been significantly expanded and updated, presenting new topics and updating coverage of other topics. Like the first edition, this second edition focuses on core online learning algorithms, with the more mathematical material set off in shaded boxes. Part I covers as much of reinforcement learning as possible without going beyond the tabular case for which exact solutions can be found. Many algorithms presented in this part are new to the second edition, including UCB, Expected Sarsa, and Double Learning. Part II extends these ideas to function approximation, with new sections on such topics as artificial neural networks and the Fourier basis, and offers expanded treatment of off-policy learning and policy-gradient methods. Part III has new chapters on reinforcement learning's relationships to psychology and neuroscience, as well as an updated case-studies chapter including AlphaGo and AlphaGo Zero, Atari game playing, and IBM Watson's wagering strategy. The final chapter discusses the future societal impacts of reinforcement learning.

Markov Decision Processes in Artificial Intelligence

The goal of machine learning is to program computers to use example data or past experience to solve a given problem. Many successful applications of machine learning exist already, including systems that analyze past sales data to predict customer behavior, optimize robot behavior so that a task can be completed using minimum resources, and extract knowledge from bioinformatics data. Introduction to Machine Learning is a comprehensive textbook on the subject, covering a broad array of topics not usually included in introductory machine learning texts. Subjects include supervised learning; Bayesian decision theory; parametric, semi-parametric, and nonparametric methods; multivariate analysis; hidden Markov models; reinforcement learning; kernel machines; graphical models; Bayesian estimation; and statistical testing. Machine learning is rapidly becoming a skill that computer science students must master before graduation. The third edition of Introduction to Machine Learning reflects this shift, with added support for beginners, including selected solutions for exercises and additional example data sets (with code available online). Other substantial changes include discussions of outlier detection; ranking algorithms for perceptrons and support vector machines; matrix decomposition and spectral methods; distance estimation; new kernel algorithms; deep learning in multilayered perceptrons; and the nonparametric approach to Bayesian methods. All learning algorithms are explained so that students can easily move from the equations in the book to a computer program. The book can be used by both advanced undergraduates and graduate students. It will also be of interest to professionals who are concerned with the application of machine learning methods.

Introduction to Deep Learning

The fundamental mathematical tools needed to understand machine learning include linear algebra, analytic geometry, matrix decompositions, vector calculus, optimization, probability and statistics. These topics are traditionally taught in disparate courses, making it hard for data science or computer science students, or professionals, to efficiently learn the mathematics. This self-contained textbook bridges the gap between mathematical and machine learning texts, introducing the mathematical concepts with a minimum of prerequisites. It uses these concepts to derive four central machine learning methods: linear regression, principal component analysis, Gaussian mixture models and support vector machines. For students and others with a mathematical background, these derivations provide a starting point to machine learning texts. For those learning the mathematics for the first time, the methods help build intuition and practical experience applying mathematical concepts. Every chapter includes worked examples and exercises to test understanding. Programming tutorials are offered on the book's web site.

Grokking Deep Learning

A comprehensive review of an area of machine learning that deals with the use of unlabeled data in classification problems: state-of-the-art algorithms, a taxonomy of the field, applications, benchmark experiments, and directions for future research. In the field of machine learning, semi-supervised learning (SSL) occupies the middle ground, between supervised learning (in which all training examples are labeled) and unsupervised learning (in which no label data are given). Interest in SSL has increased in recent years, particularly because of application domains in which unlabeled data are plentiful, such as images, text, and bioinformatics. This first comprehensive overview of SSL presents state-of-the-art algorithms, a taxonomy of the field, selected applications, benchmark experiments, and perspectives on ongoing and future research. Semi-Supervised Learning first presents the key assumptions and ideas underlying the field: smoothness, cluster or low-density separation, manifold structure, and transduction. The core of the book is the presentation of SSL methods, organized according to algorithmic strategies. After an examination of generative models, the book describes algorithms that implement the low-density separation assumption, graph-based methods, and algorithms that perform two-step learning. The book then discusses SSL applications and offers guidelines for SSL practitioners by analyzing the results of extensive benchmark experiments. Finally, the book looks at interesting directions for SSL research. The book closes with a discussion of the relationship between semi-supervised learning and transduction.

Reinforcement Learning and Dynamic Programming Using Function Approximators

The significantly expanded and updated new edition of a widely used text on reinforcement learning, one of the most active research areas in artificial intelligence. Reinforcement learning, one of the most active research areas in artificial intelligence, is a computational approach to learning whereby an agent tries to maximize the total amount of reward it receives while interacting with a complex, uncertain environment. The second part of the book (Parts III and IV) introduces more specialized neural network architectures, including 1D convolutional neural networks, recurrent neural networks, conditioned-generation models, and attention-based models. These architectures and techniques are the driving force behind state-of-the-art algorithms for machine learning, syntactic parsing, and many other applications. Finally, we also discuss tree-shaped networks, structured prediction, and the prospects of multi-task learning.
An Introduction to Deep Reinforcement Learning

Reinforcement learning with python Although it has been around for decades, the concept of Reinforcement Learning has reached its peak a couple of years ago. Since then, the technology industry has been updating robots and presenting innovative machines on the market that none of us knew could exist. If this is something that excites you and you have a decent programming skills, then this book will help you master reinforcement learning.

Neural Network Methods in Natural Language Processing

Summary Grokking Deep Learning teaches you to build deep learning neural networks from scratch! In his engaging style, seasoned deep learning expert Andrew Trask shows you the science under the hood, so you grok for yourself every detail of training neural networks. Purchase of the print book includes a free eBook in PDF, Kindle, and ePub formats from Manning Publications. About the Technology Deep learning, a branch of artificial intelligence, teaches computers to learn by using neural networks, technology inspired by the human brain. Online text translation, self-driving cars, personalized product recommendations, and virtual voice assistants are just a few of the exciting modern advancements possible thanks to deep learning. About the Book Grokking Deep Learning teaches you to build deep learning neural networks from scratch! In his engaging style, seasoned deep learning expert Andrew Trask shows you the science under the hood, so you grok for yourself every detail of training neural networks. Using only Python and its math-supporting library, NumPy, you’ll train your own neural networks to see and understand images, translate text into different languages, and even write like Shakespeare! When you’re done, you’ll be fully prepared to move on to mastering deep learning frameworks. What’s inside The science behind deep learning Building and training your own neural networks Privacy concepts, including federated learning Tips for continuing your pursuit of deep learning About the Reader For readers with high school-level math and intermediate programming skills. About the Author The Author Author Trask is a PhD student at Oxford University and a research scientist at DeepMind. Previously, Andrew was a researcher and analytics product manager at Digital Reasoning, where he trained the world’s largest artificial neural network and helped guide the analytics roadmap for the Synthesys cognitive computing platform. Table of Contents Introducing deep learning: why you should learn it Fundamental concepts: how do machines learn? Introduction to neural prediction: forward propagation Introduction to neural learning: gradient descent Learning multiple weights at a time: generalizing gradient descent Building your first deep neural network: introduction to backpropagation How to picture neural networks: in your head and on paper Learning signal and ignoring noise: introduction to regularization and batching Modeling probabilities and nonlinearities: activation functions Neural learning about edges and corners: intro to convolutional neural networks Neural networks that understand language: king - man + woman == ? Neural networks that write like Shakespeare: recurrent layers for variable-length data Introducing automatic optimization: let’s build a deep learning framework Learning to write like Shakespeare: long short-term memory Deep learning on unseen data: introducing federated learning Where to go from here: a brief guide

Reinforcement Learning with Python

The notion of artificial intelligence (AI) often sparks thoughts of characters from science fiction, such as the Terminator and HAL 9000. While these two artificial entities do not exist, the algorithms of AI have been able to address many real issues, from performing medical diagnoses to navigating difficult terrain to monitoring possible failures of spacecrafts. Exploring these algorithms and applications, Contemporary Artificial Intelligence presents strong AI methods and algorithms for solving challenging problems involving systems that behave intelligently in specialized domains such as medical and software diagnostics, financial decision making, speech and text recognition, genetic analysis, and more. One of the first AI texts accessible to students, the book focuses on the most useful problem-solving strategies that have emerged from AI. In a student-friendly way, the authors cover logic-based methods; probability-based methods; emergent intelligence, including evolutionary computation and swarm intelligence; data-derived logical and probabilistic learning models; and natural language understanding. Through reading this book, students discover the importance of AI techniques in computer science.

Deep Reinforcement Learning with Python

Brains rule the world, and brain-like computation is increasingly used in algorithms and electronic devices. Brain-like computation is about processing and interpreting data or directly putting forward and performing actions. Learning is a very important aspect. This book is on reinforcement learning which involves performing actions to achieve a goal. The first 11 chapters of this book describe and extend the scope of reinforcement learning. The remaining 11 chapters show that there is already wide usage in numerous fields. Reinforcement learning can tackle control tasks that are too complex for traditional, hand-designed, non-learning controllers. As learning computers can deal with technical complexities, the tasks of human operators remain to specify goals on increasingly higher levels. This book shows that reinforcement learning is a very dynamic area in terms of theory and applications and it shall stimulate and encourage new research in this field.

Reinforcement Learning, second edition

New edition of the bestselling guide to deep reinforcement learning and how it’s used to solve complex real-world problems. Revised and expanded to include multi-agent methods, discrete optimization, RL in robotics, advanced exploration techniques, and more Key Features Second edition of the bestselling introduction to deep reinforcement learning, expanded with six new chapters Learn advanced exploration techniques including noisy networks, pseudo-count, and network distillation methods Apply RL methods to cheap hardware robotics platforms Book Description Deep Reinforcement Learning Hands-On, Second Edition is an updated and expanded version of the bestselling guide to the very latest reinforcement learning (RL) tools and techniques. It provides you with an introduction to the fundamentals of RL, along with the hands-on ability to code intelligent learning agents to perform a range of practical tasks. With six new chapters devoted to a variety of up-to-the-minute developments in RL, including discrete optimization (solving the Rubik’s Cube), multi-agent methods, Microsoft’s TextWorld environment, advanced exploration techniques, and more, you will come away from this book with a deep understanding of the latest innovations in this emerging field. In addition, you will gain actionable insights into such topic areas as deep Q-networks, policy gradient methods, continuous control problems, and highly scalable, non-gradient methods. You will also discover how to build a real hardware robot trained with RL for less than $100 and solve the Pong environment in just 30 minutes of training using step-by-step code optimization. In short, Deep Reinforcement Learning Hands-On, Second Edition, is your companion to navigating the exciting complexities of RL as it helps you attain experience and knowledge through real-world examples. What you
will learn understand the deep learning context of RL and implement complex deep learning models. Evaluate RL methods including cross-entropy, DQN, actor-critic, TRPO, PPO, DDPG, D4PG, and others. Build a practical hardware robot trained with RL methods for less than $100. Discover Microsoft’s TextWorld environment, which is an interactive fiction games platform. Use discrete optimization in RL to solve a Rubik’s Cube. Teach your agent to play Connect 4 using AlphaZero. Explore the very latest deep RL research on topics including AI chatbots. Discover advanced exploration techniques, including noisy networks, and network distillation techniques. Who this book is for: Some fluency in Python is assumed. Sound understanding of the fundamentals of deep learning will be helpful. This book is an introduction to deep RL and requires no background in RL.

**Learning in Embedded Systems**

The first edition of this popular textbook, Contemporary Artificial Intelligence, provided an accessible and student-friendly introduction to AI. This fully revised and expanded update, Artificial Intelligence: With an Introduction to Machine Learning, Second Edition, retains the same accessibility and problem-solving approach, while providing new material and methods. The book is divided into five sections that focus on the most useful techniques that have emerged from AI. The first section of the book covers logic-based methods, while the second section focuses on probability-based methods. Emergent intelligence is featured in the third section and explores evolutionary computation and methods based on swarm intelligence. The newest section comes next and provides a detailed overview of neural networks and deep learning. The final section of the book focuses on natural language understanding. Suitable for undergraduate and beginning graduate students, this class-tested textbook provides students and other readers with key AI methods and algorithms for solving challenging problems involving systems that behave intelligently in specialized domains such as medical and software diagnostics, financial decision making, speech and text recognition, genetic analysis, and more.

**Mathematics for Machine Learning**

Neural Networks for Control brings together examples of all the most important paradigms for the application of neural networks to robotics and control. Primarily concerned with engineering problems and approaches to their solution through neurocomputing systems, the book is divided into three sections: general principles, motion control, and applications domains (with evaluations of the possible applications by experts in the applications areas.) Special emphasis is placed on designs based on optimization or reinforcement, which will become increasingly important as researchers address more complex engineering challenges or real biological-control problems. A Bradford Book. Neural Network Modeling and Connectionism series.

**Decision Making Under Uncertainty**

Deep reinforcement learning is a fast-growing discipline that is making a significant impact in fields of autonomous vehicles, robotics, healthcare, finance, and many more. This book covers deep reinforcement learning and policy gradient models with coding exercise. You’ll begin by reviewing the Markov decision processes, Bellman equations, and dynamic programming that form the core concepts and foundation of deep reinforcement learning. Next, you’ll study model-free learning followed by function approximation using neural networks and deep learning. This is followed by various deep reinforcement learning algorithms such as deep q-networks, various flavors of actor-critic methods, and other policy-based methods. You’ll also look at exploration vs exploitation dilemma, a key consideration in reinforcement learning algorithms, along with Monte Carlo tree search (MCTS), which played a key role in the success of AlphaGo. The final chapters conclude with deep reinforcement learning implementation using popular deep learning frameworks such as TensorFlow and PyTorch. In the end, you’ll understand deep reinforcement learning along with deep q networks and policy gradient models implementation with TensorFlow, PyTorch, and OpenAI Gym. What You’ll Learn: Examine deep reinforcement learning Implement deep learning algorithms using OpenAI’s Gym environment Code your own game playing agents for Atari using actor-critic algorithms Apply best practices for model building and algorithm training. Who This Book Is For: Machine learning developers and architects who want to stay ahead of the curve in the field of AI and deep learning.

**Bayesian Reasoning and Machine Learning**

Reinforcement learning (RL) will deliver one of the biggest breakthroughs in AI over the next decade, enabling algorithms to learn from their environment to achieve arbitrary goals. This exciting development avoids constraints found in traditional machine learning (ML) algorithms. This practical book shows data science and AI professionals how to learn by reinforcement and enable a machine to learn by itself. Author Phil Winder of Winder Research covers everything from basic building blocks to state-of-the-art practices. You’ll explore the current state of RL, focus on industrial applications, learn numerous algorithms, and benefit from dedicated chapters on deploying RL solutions to production. This is no cookbook; doesn’t shy away from math and explores familiarity with ML. Learn what RL is and how the algorithms help solve problems. Become grounded in RL fundamentals including Markov decision processes, dynamic programming, and temporal difference learning. Dive deep into a range of value and policy gradient methods. Apply advanced RL solutions such as meta learning, hierarchical learning, multi-agent, and imitation learning. Understand cutting-edge deep RL algorithms including Rainbow, PPO, TD3, SAC, and more. Get practical examples through the accompanying website.

**Grokking Deep Reinforcement Learning**

An introduction to a broad range of topics in deep learning, covering mathematical and conceptual background, deep learning techniques used in industry, and research perspectives. “Written by three experts in the field, Deep Learning is the only comprehensive book on the subject.” —Elon Musk, cochair of OpenAI; cofounder and CEO of Tesla and SpaceX. Deep learning is a form of machine learning that enables computers to learn from experience and understand the world in terms of a hierarchy of concepts. Because the computer gathers knowledge from experience, there is no need for a human computer operator to formally specify all the knowledge that the computer needs. The hierarchy of concepts allows the computer to learn complicated concepts by building them out of simpler ones; a graph of these hierarchies would be many layers deep. This book introduces a broad range of topics in deep learning. The text offers mathematical and conceptual background, covering relevant concepts in linear algebra, probability theory and information theory, numerical computation, and machine learning. It describes deep learning techniques used by practitioners in industry, including deep feedforward networks, regularization, optimization algorithms, convolutional networks, sequence modeling, and practical methodology; it surveys such applications as natural language processing, speech recognition, computer vision, online recommendation systems, bioinformatics, and videogames. Finally, the book offers research perspectives, covering such theoretical topics as linear factor models, autoencoders, representation learning, structured probabilistic models, Monte Carlo methods, the partition function, approximate inference, and deep generative models. Deep Learning can be used by undergraduate or graduate students planning careers in either industry.
or research, and by software engineers who want to begin using deep learning in their products or platforms. A website offers supplementary material for both readers and instructors.

**Deep Learning with JavaScript**

Learning to perform complex action strategies is an important problem in the fields of artificial intelligence, robotics, and machine learning. Filled with interesting new experimental results, Learning in Embedded Systems explores algorithms that learn efficiently from trial-and-error experience with an external world. It is the first detailed exploration of the problem of learning action strategies in the context of designing embedded systems that adapt their behavior to a complex, changing environment; such systems include mobile robots, factory process controllers, and long-term software databases. Kaelbling investigates a rapidly expanding branch of machine learning known as reinforcement learning, including the important problems of controlled exploration of the environment, learning in highly complex environments, and learning from delayed reward. She reviews past work in this area and presents a number of significant new results. These include the interval estimation algorithm for exploration, the use of biases to make learning more efficient in complex environments, a generate-and-test algorithm that combines symbolic and statistical processing into a flexible learning method, and some of the first reinforcement-learning experiments with a real robot.

**Reinforcement Learning**

Deep reinforcement learning is the combination of reinforcement learning (RL) and deep learning. This field of research has recently been able to solve a wide range of complex decision-making tasks that were previously out of reach for a machine. Deep RL opens up many new applications in domains such as healthcare, robotics, smart grids, finance, and many more. This book provides the reader with a starting point for understanding the topic. Although written at a research level it provides a comprehensive and accessible introduction to deep reinforcement learning models, algorithms and techniques. Particular focus is on the aspects related to generalization and how deep RL can be used for practical applications. Written by recognized experts, this book is an important introduction to Deep Reinforcement Learning for practitioners, researchers and students alike.

**Contemporary Artificial Intelligence**

"Reinventing Discovery argues that we are in the early days of the most dramatic change in how science is done in more than 300 years. This change is being driven by new online tools, which are transforming and radically accelerating scientific discovery"—Provided by publisher.

**Deep Reinforcement Learning Hands-On**

A comprehensive and rigorous introduction for graduate students and researchers, with applications in sequential decision-making problems.

**Introduction to Machine Learning**

This practical guide will teach you how deep learning (DL) can be used to solve complex real-world problems. Key Features Explore deep reinforcement learning (RL), from the first principles to the latest algorithms Evaluate high-profile RL methods, including value iteration, deep Q-networks, policy gradients, TRPO, PPO, DDPG, D4PG, evolution strategies and generic algorithms Keep up with the very latest industry developments, including AI-driven chatbots Book Description Recent developments in reinforcement learning (RL), combined with deep learning (DL), have seen unprecedented progress made towards training agents to solve complex problems in a human-like way. Google's use of algorithms to play and defeat the well-known Atari arcade games has propelled the field to prominence, and researchers are generating new ideas at a rapid pace. Deep Reinforcement Learning Hands-On is a comprehensive guide to the very latest DL tools and their limitations. You will evaluate methods including Cross-entropy and policy gradients, before applying them to real-world environments. Take on both the Atari set of virtual games and family favorites such as Connect4. The book provides an introduction to the basics of RL, giving you the know-how to code intelligent learning agents to take on a formidable array of practical tasks. Discover how to implement Q-learning on 'grid world' environments, teach your agent to play Connect4 using AlphaGo Zero Explore the very latest deep RL research on topics including AI-driven chatbots Who this book is for Some fluency in Python is assumed. Basic deep learning (DL) approaches should be familiar to readers and some practical experience in DL will be helpful. This book is an introduction to deep reinforcement learning (RL) and requires no background in RL.

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